



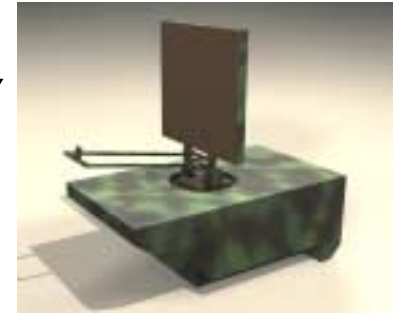
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ACTIVE DENIAL SYSTEM (ADS)



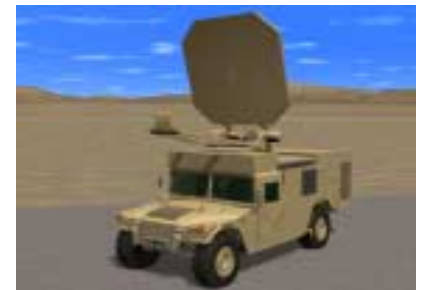
**ADVANCED CONCEPT TECHNOLOGY
DEMONSTRATION (ACTD)**

Breakfast Club Briefing



Proposed by

**JOINT NON-LETHAL WEAPONS
DIRECTORATE (JNLWD)**



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PURPOSE

(Tourist or Terrorist?)

Provide Long-Range Non-Lethal Weapon Capability:

- Politically Constrained Situations
 - When Use of Lethal Force Not Optimal Response
 - U.S. Lacks Long-Range Non-Lethal Option
 - Discriminates Threat, Stand-off, Delay Time
 - SAVES LIVES
- Mission Examples:
 - Navy: Harbor, Small Boat Defense
 - Army, Marines: Peace Support Ops, MOUT, Crowd Control, Area Denial
 - AF: Protect Forces, High Value National Assets



**Better NLW
Capability
Supported By
PACOM, EUCOM,
USFK**

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ADS Fills Non-Lethal Capability Gap



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WARFIGHTER NEEDS

- **All Services + SOCOM Seek NL Capabilities**
 - Published MNS (12+)
- **Present NL Capability Very Limited**
 - Presence, Conventional Blunt Impact Munitions, OC
 - Limited Range & Effectiveness, Injury Risk
- **Politically Constrained Missions**
 - Alliances, CNN Factor, Multi-National, etc.
- **Asymmetric Engagements**
 - No Peer Competitor, Adversaries Exploit Capability Gaps

Mission Effectiveness Benefits from NL Force Option

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USER INTEREST

- **Adm Blair (CINCPAC): P4 to CJCS, JCS**
 - **ADS #1 Force Protection Development Priority**
- **Gen Fulford (DCINCEUR):**
 - **“How Soon Can You Get This to Kosovo?”**
- **Gen Martin (USAFE/CC):**
 - **# 1 Desired DE Capability: Incapacitate People**
- **MSgt Tim Wilkinson (AF Cross, Somalia):**
 - **Repel Capability Would Have**
 - **Avoided 15 hr BLACKHAWK DOWN Firefight**
 - **Saved Lives of Non-combatants**



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ADS CONCEPT

- **Non-Lethal Anti-Personnel Directed Energy Weapon**
- **Many Potential Platforms (Maritime, Vehicle, etc.)**
- **Direct Fire Suppression Weapon**
 - **Outranges Effective Small Arms Fire**
 - **Deep Magazine, Speed-of-Light, Line-of-Sight**
- **Energy Beam Heats Adversary's Skin, Causes Intense Pain, But Not Damage, Forces Adversary to Flee**
 - **Pulsed/Continuous, Dwelt or Swept Beam**



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PROGRAM BACKGROUND

- **Active Denial Ideas Started mid-80s**
- **SAC Statement of Need: 1987**
 - **NL Technology to Guard Nuclear Weapons**
- **Program Originally Funded by PSEAG (Physical Security Equipment Action Group)**
- **1994: Started Investigating Repel Effect**
- **1996: Successful Field Demo of Repel (Goats)**
- **1997: Funding from JNLWD for Vehicle ADT**
- **1998: Battlelab Demo Initiated, Funding Increased**
- **Mar 2001: Battlelab Demo Exit Criteria Passed**
- **May 2001: Safely Demo'd Robust Repel Effect at Full Weapons Parameters on People at Range in Field**

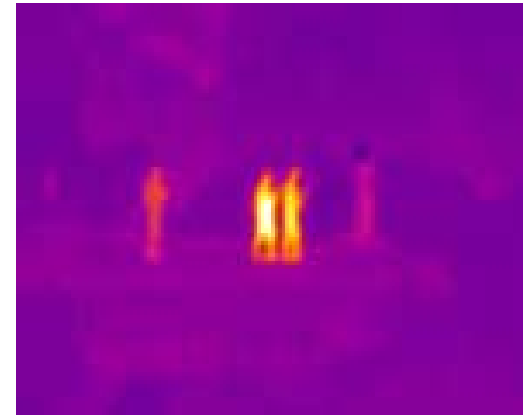
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PROGRAM STATUS

- **Mature Technology**
 - **Successful Battlelab Demo in Field at Test Range**
- **Repel Effect Safely Demonstrated**
 - **Volunteers**
 - **Full Weapons Parameters**
- **Passed Preliminary Legal Review**
 - **Navy JAG, Services Concurrence**
- **Favorable Ops Utility Assessment by Joint Requirements Group**
- **Lack CONOPS, ORDs**
 - **Hesitancy With Revolutionary Technology/Capability**



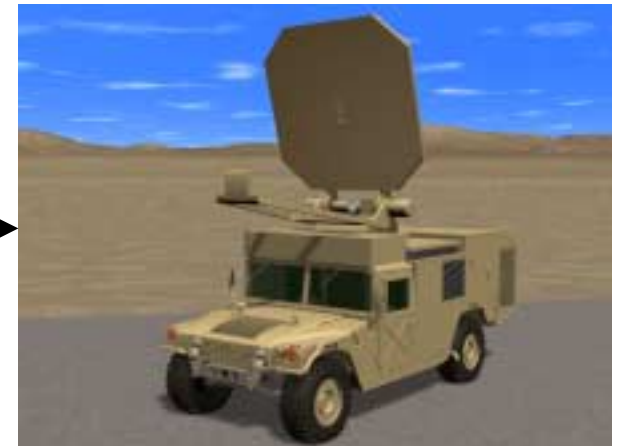


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TECHNOLOGY ADVANCES

**Bio-Effects
Understanding**

**Effects, Sources and Antenna
Advances Enable Application**



- **Successful FP Battlelab Demo FY01**
- **Proposed ACTD Start FY02**

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FLIR MOVIE

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BIO-EFFECTS

- RF Bio-Effects Research is Basis of ADT Program

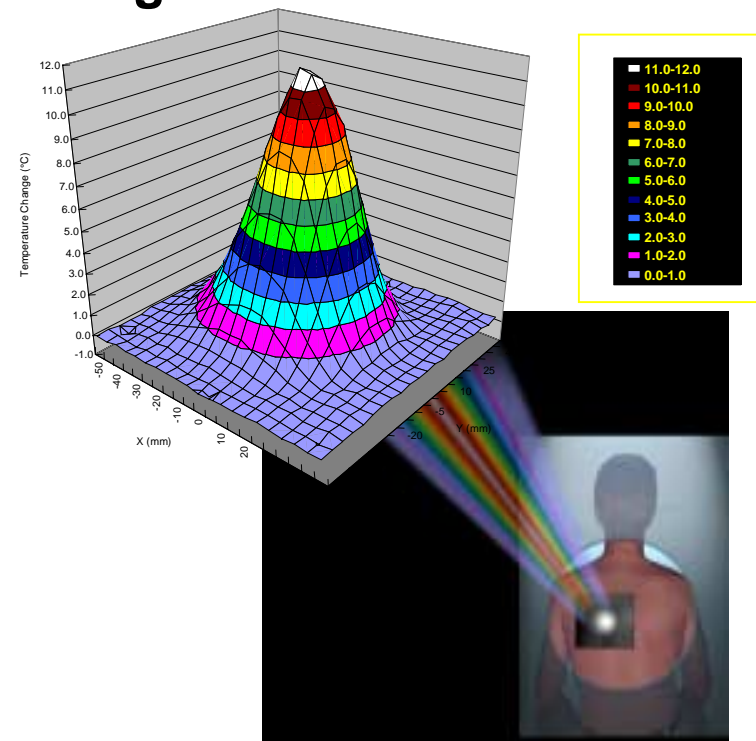
- System Design
- Technology Development
- Legal/Policy/Public Acceptability

- Basic Bio-Effects Quantified

- Animal, Human Experiments
- Pain Threshold, Pain Intolerance
- Study at Weapons-Level Fluences
- Models Consistent With Data

- Wide Separation Between Desired, Undesired Effects

- No Long Term Effects



Human Skin Heating Experiment
Using Infrared Thermography



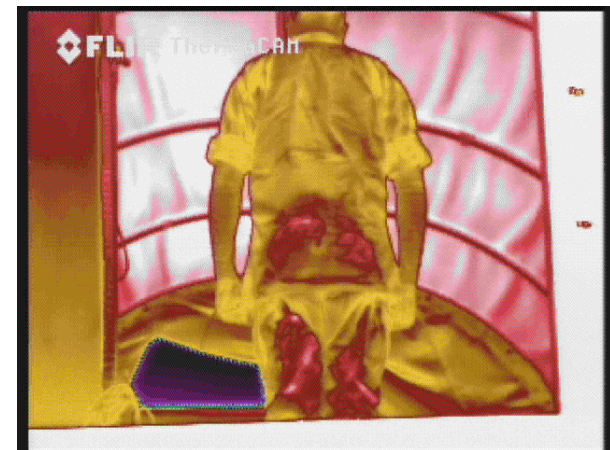
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HUMAN REPEL EXPERIMENTS

- Repel Effect Safely Demo'd
 - More Than 40 Subjects
 - Tactically Significant Range
- Repel More Robust Than Predicted
 - Large Spot Size
 - Lower Endpoint Skin Temp
- Increases Effectiveness, Safety Margin
- All Subjects Are Volunteers
- Approved Human Use Protocol
- Back Exposures Only
 - Frontal Exposures Planned



Video Camera Data Shot



IR Slow Motion

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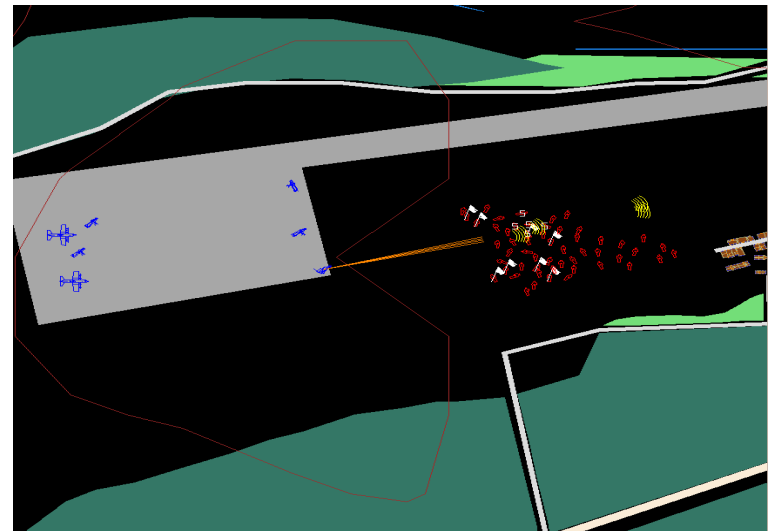
BATTLELAB DEMO



Demo Hardware

- Demonstrate Beam on Target
- Power Density, Dwell, Spot Size at Range
- Greatly Exceeded BL Demo Exit Criteria
- Proved Beam Propagation

- FP Battlelab Demo Success!
- Three Phases: M&S, Live Force-on-Force, Tech Demo
- Assess Potential Op Utility
- Demo Critical Technologies



M&S: AFSOC Force Protection Scenario

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PROJECTED OPERATIONAL CAPABILITY

- **Beam Employment:**
 - **Head-on Repel**
 - **Beam Sweeping - Area Effect, Crowd Control**
 - **Barrier, Suppression**
- **Discriminate “Tourist or Terrorist”**
 - **Separate Combatants from Non-Combatants**
 - **Partition Crowd, Isolate Agitators, Attack Leaders**
- **Separate Troops in Contact**
- **Long Range Engagements**
- **ADS Can Validate Hostile Intent**
 - **Avoid Surprise**
 - **Increases Stand-off, Delay Time**

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ADS ACTD SCHEDULE

Tasks	FY02			FY03			FY04			FY05			FY06		
ACTD Approval	◆														
Design															
COE Study															
Requirements Dev															
Optimize Source															
Effects Testing															
Build															
Field Test/Demo															
ADS Demos															
Residual															



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ADS ACTD MANAGEMENT

Proposed Stakeholders

- EA/Lead Service: Navy
- CINC Sponsor: PACOM
- Supporting CINC: EUCOM

Proposed Program Execution

- Demo Mgr: NAVSEA (AFRL)
- Ops Mgr: PACOM
- Transition Mgr: NAVSEA

Validation Processes

- Operational Utility Assessment
- Red Team
- Analysis of Alternatives



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ADS ACTD FUNDING

Option 1: One Residual ADS

Funding	FY02	FY03	FY04	FY05	FY06	Totals
Navy	TBD	TBD	TBD	TBD	TBD	TBD
JNLWD	10.8	4	TBD	TBD	TBD	14.8
DUSD	0.5	1.4	6.7	3	3	14.6
Total Funding	11.3	5.4	6.7	3	3	29.4

Pending
Funded
Proposed

Option 2: Two Residual ADS

Funding (\$M)	FY02	FY03	FY04	FY05	FY06	Totals
Navy	TBD	TBD	TBD	TBD	TBD	TBD
JNLWD	10.8	4	TBD	TBD	TBD	14.8
DUSD	0.5	1.4	6.7	3	3	14.6
Add'l Naval System	2	4	3	1	1	11
Total Funding	13.3	9.4	9.7	4	4	40.4

Pending
Funded
Proposed
Proposed

Note 1: JNLWD Funding Includes Force Protection Supplemental in PBD 810 (\$7.8M) in FY02

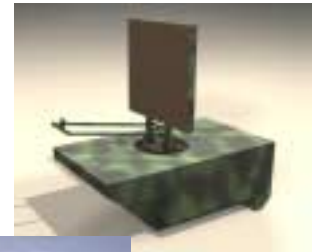
Note 2: Additional ~\$2M Required to Configure Option 1 for Naval Apps

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UNCLASSIFIED RESIDUALS

- **ADS System(s)**
 - Fully Functional: Range, Power, Targeting/Sensor
 - Packaged for Naval/Joint Application
 - 80%+ Solution: “Go to War” Residual
- **Military Utility**
 - Viable CONOPS (Explore Joint Solutions)
 - Establish Requirements
 - Red Team Evaluation
- **Acquisition Process**
 - User/Service Informed Decision (Try Before Buy)
 - Accelerate Acquisition Process
 - Reduce Risk, Cost
- **Other**
 - Bio-Effects Knowledge Database (Legal/Public Acceptability)
 - Policy, Doctrine, & Training - Issues & Answers





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SUMMARY

- **Revolutionary Force Protection Capability**
 - Facilitates Discrimination - Tourist or Terrorist?
 - Saves Lives
 - Energy Weapon: Long Range, Deep Magazine
- **Establishes Warfighter Involvement**
 - CONOPS, Requirements, Red Team Evaluation
 - Try Before Buy
- **Supplies Real Hardware Residual(s)**
- **Facilitates Acquisition**
 - Reduces Risk, Cost

ADS: Non-Lethal Dominance for the 21st Century



Back-Up Slides

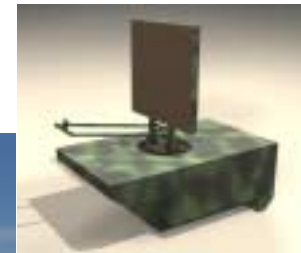


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ACTIVE DENIAL SYSTEM (ADS)

Objective: Provide Long-Range Anti-Personnel Non-Lethal Force Option to Commanders

- Package Powerful mm-Wave Transmitter
- Validate Weapon Effectiveness & Safety in Field Testing, Develop CONOPS
- Transition Residual to Warfighters for Further Evaluation



Residual: One ADS System

Participants: JNLWD, AF, Navy, PACOM

Schedule/Funding:

Tasks	FY02	FY03	FY04	FY05	FY06	
ACTD Approval	◆					
Design	■					
COE Study	■	■				
Requirements Dev	■	■	■			
Optimize Source	■	■	■	■		
Effects Testing	■	■	■	■	■	
Build		■	■	■		
Field Test/Demo				■	■	
ADS Demos				◆	◆	
Residual				■	■	■

Source	Prior Yr	FY02	FY03	FY04	FY05	FY06	Totals	Status
AF Funding	22						22	Expended
JNLWD Funding	19.7	10.8	4	0	0		34.5	Funded
DUSD Funding		0.5	1.4	6.7	3	3	14.6	Proposed

Technology:

- Powerful Efficient mm-Wave Source
- Beam Transport, High Gain Antenna
- Generator/Li-Ion Battery Power System
- Safe Repel Demos in Field at Range: May 01
- Energy Beam Heats Skin, Causes Repel

Risk:

- Medium Technical Risk

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LEGAL/POLICY STATUS (U)

(U) VMADS Has Passed Preliminary Weapons Legal Review

(U) Conducted by Navy JAG, Input from Services

(U) Complies with LOAC, Treaty Obligations

(U) Proportional, Discriminate

(U) No Long-Term or Unnecessary Suffering

(U) VMADS Complies With DoD Non-Lethal Weapons Policy

(U) Minimize Casualties, Damage to Materiel

(U) More Complete Legal Review Being Studied By AF

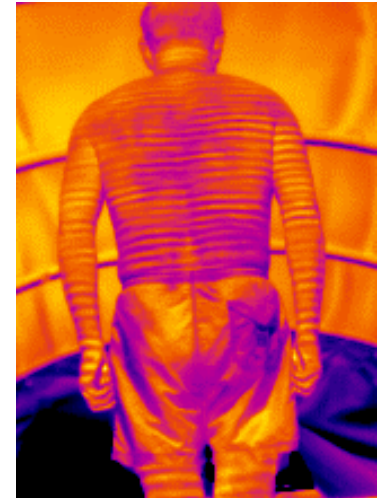
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EFFECTS MODEL

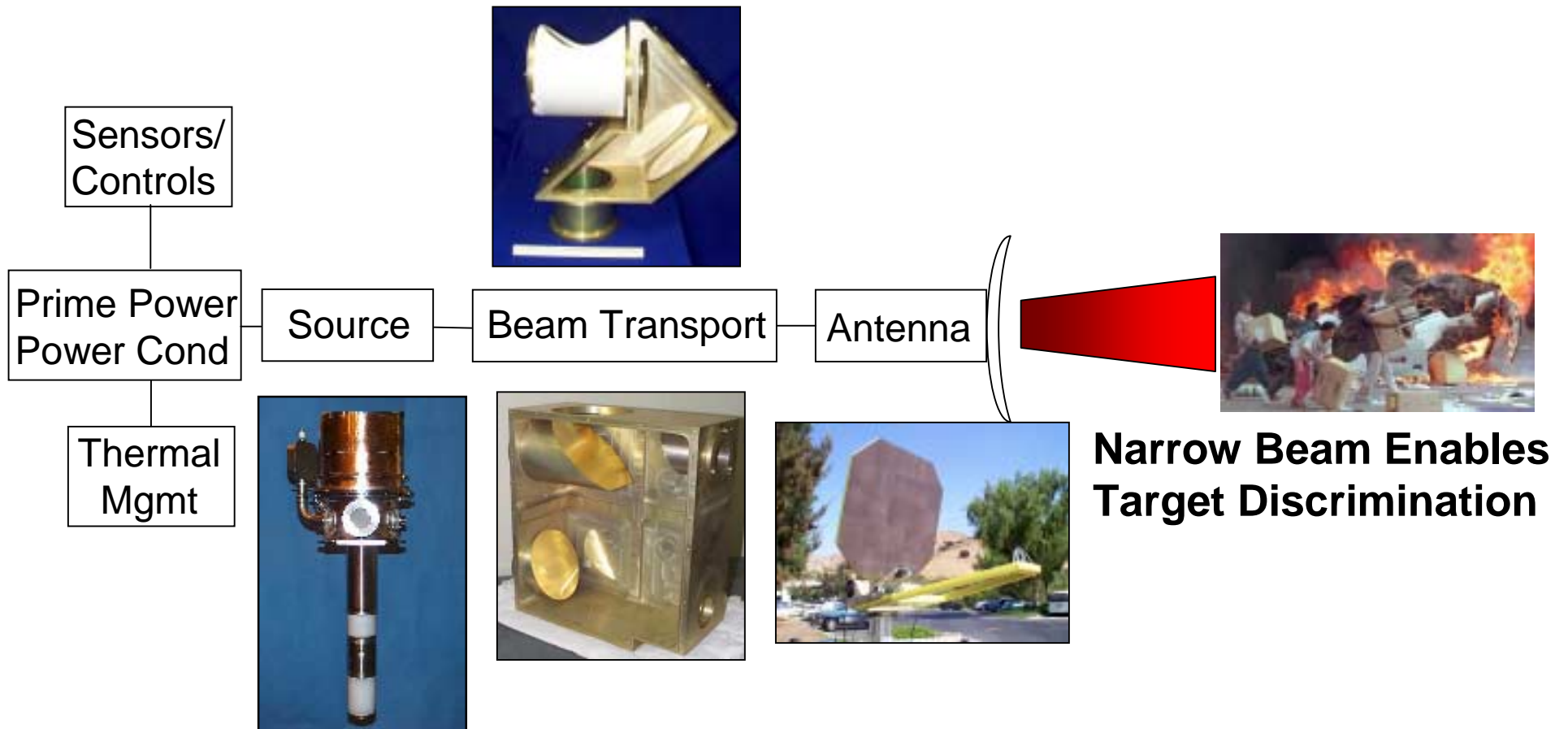
- System Projects Energy Beam at Target
- Effect Depends on Power Density and Duration
 - Model Includes Atmospheric Attenuation, Losses
- Human Effects Data for Skin Heating
- Literature Relates Pain Intensity to Skin Temp
- Model Predicts Time to Effect (Pain Intensity)
- Ongoing Field Experiments Yield Repel P_E vs Power Density on Target





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SYSTEM TECHNOLOGIES



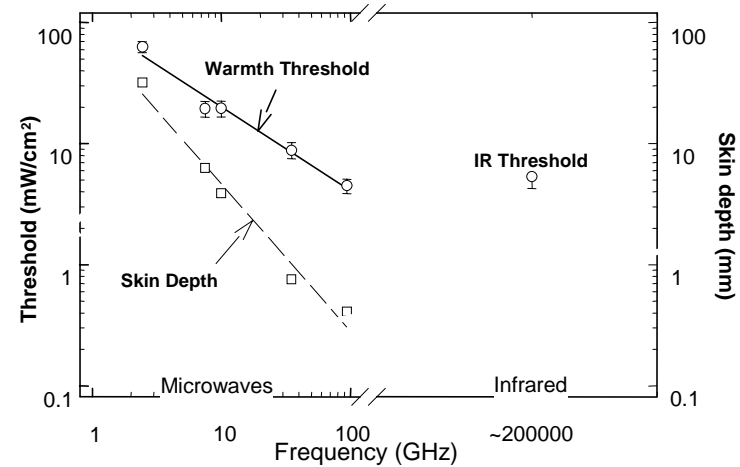
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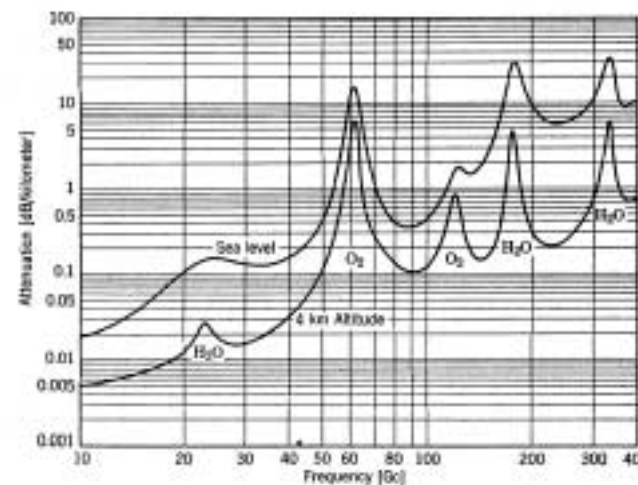
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REPEL FREQUENCY (U)

- (U) 95 GHz
- (U) Scaling of Biological Effect (less P_d at higher f)
- (U) Availability of Source Technology
- (U) Atmospheric Propagation Window
- (U) Scaling of Antenna Gain
 $G \propto f^2$ (In Far-Field)



Penetration Depth vs Frequency



Atmospheric Attenuation vs Frequency

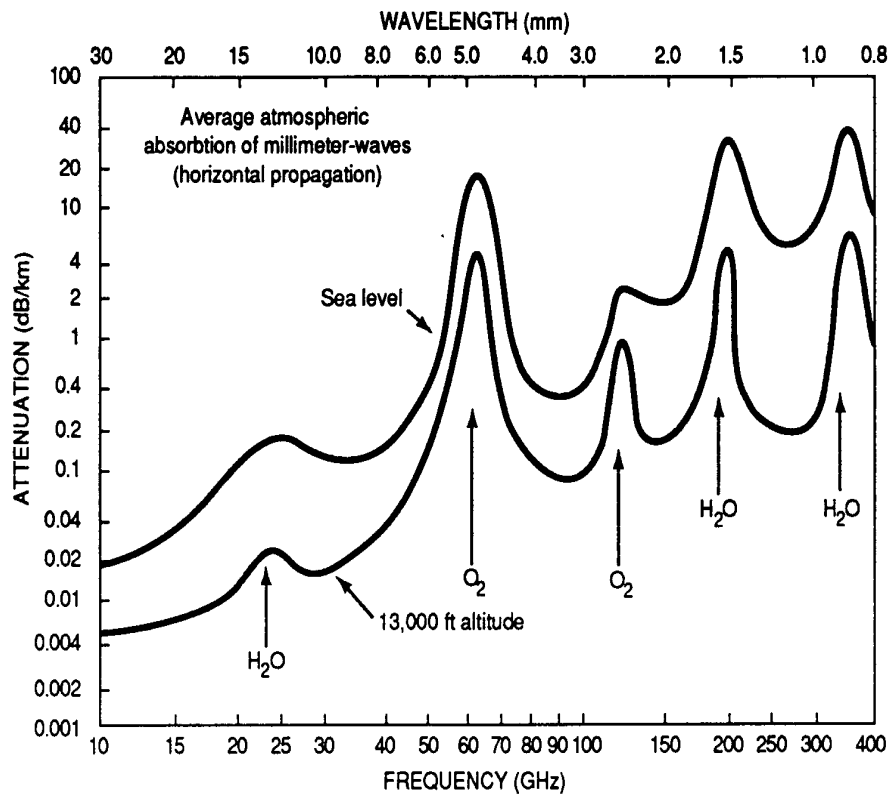
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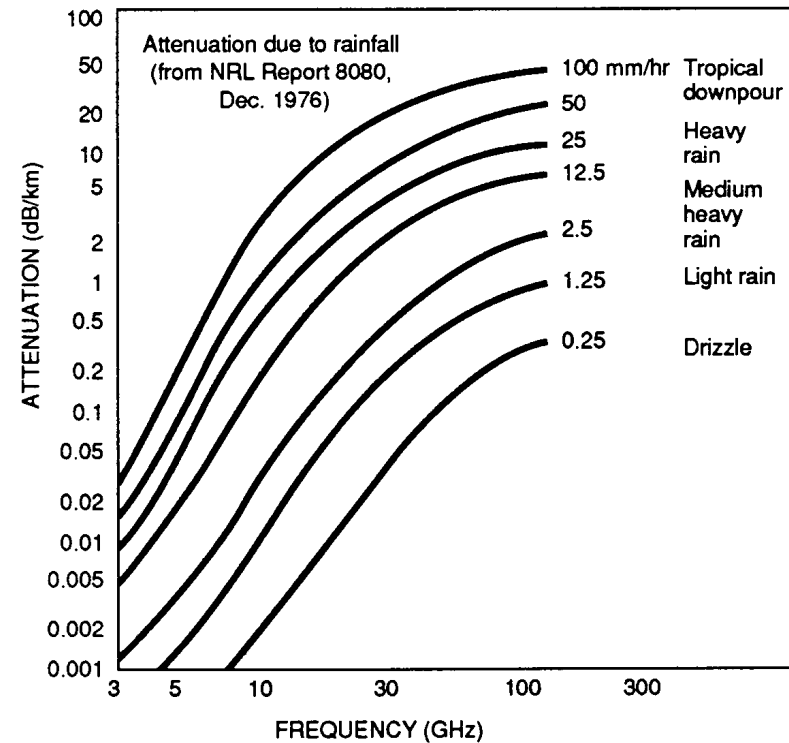
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ATMOSPHERIC EFFECTS (U)

Clear Air RF Attenuation



Effect of Rain on RF Propagation

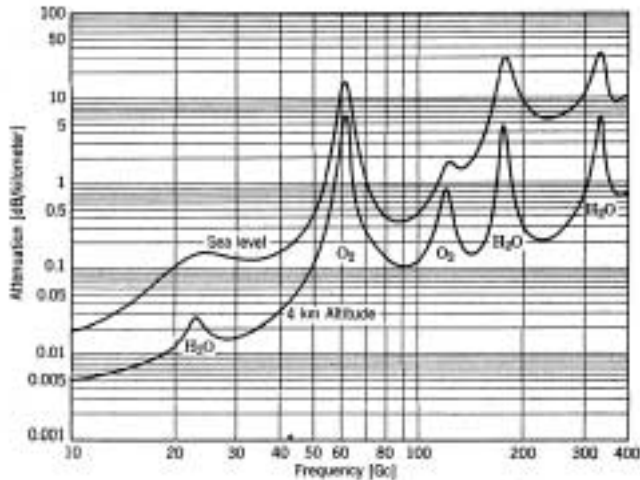


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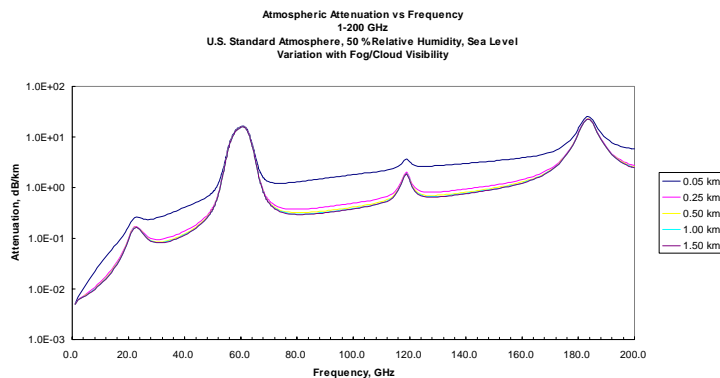


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ATMOSPHERIC ATTENUATION (U)



Atmospheric Attenuation vs Frequency



Attenuation Thru Fog

(U) Attenuation Varies With Atmospheric Conditions

(U) Humidity, Altitude, Rain, Fog All Affect Attenuation

(U) Turbulence Can Cause Scintillation
– Not Significant for mm-Waves 1 km

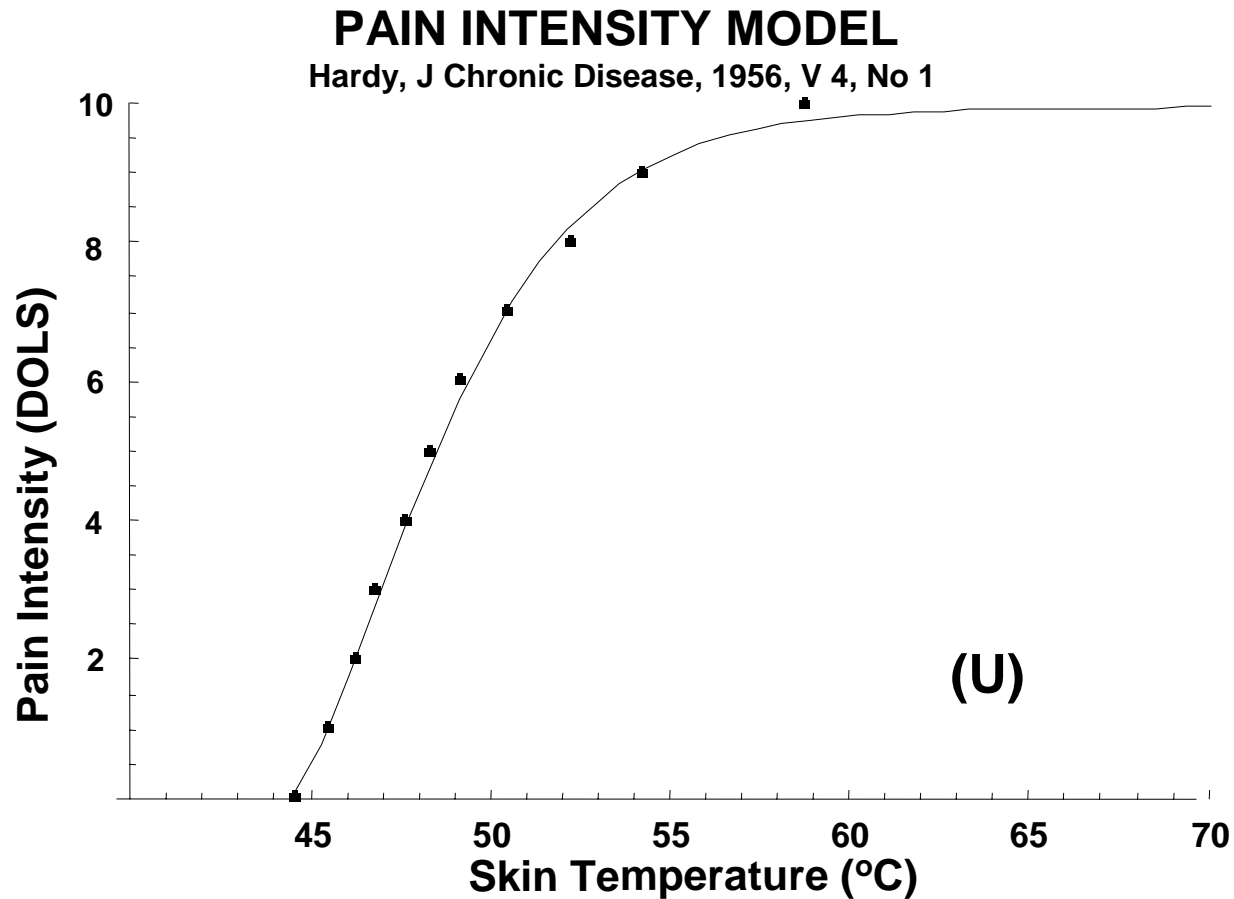
(U) Atmospheric Propagation Code from Univ. Colorado, Boulder Predicts Attenuation Effects Accurately

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THERMAL PAIN (U)



(U) Pain intensity strongly dependent on skin temperature

(U) Skin pain threshold is independent of age, gender, race, species

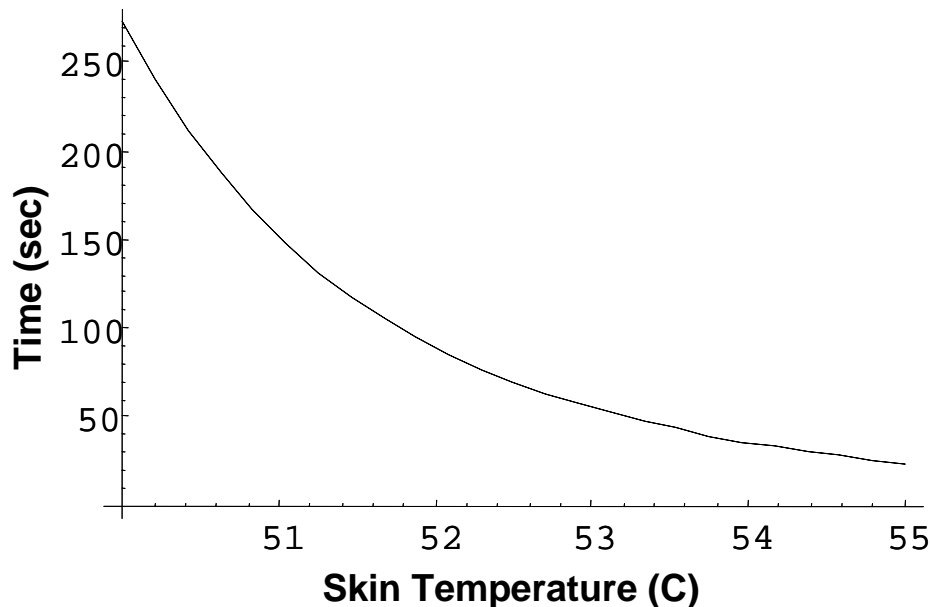
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NO LONG TERM EFFECTS (U)

Time to Burn vs Skin Temp



(U) Repel Exploits Natural Defense Mechanism: Pain

(U) Little Variability in Human Pain Response

(U) Figure Shows Large Safety Margin Before Burn

(U) Experiments Show Blink Reflex Negates Possibility of Eye Damage

(U) Cancer Initiation Not Possible Due to Low Photon Energy

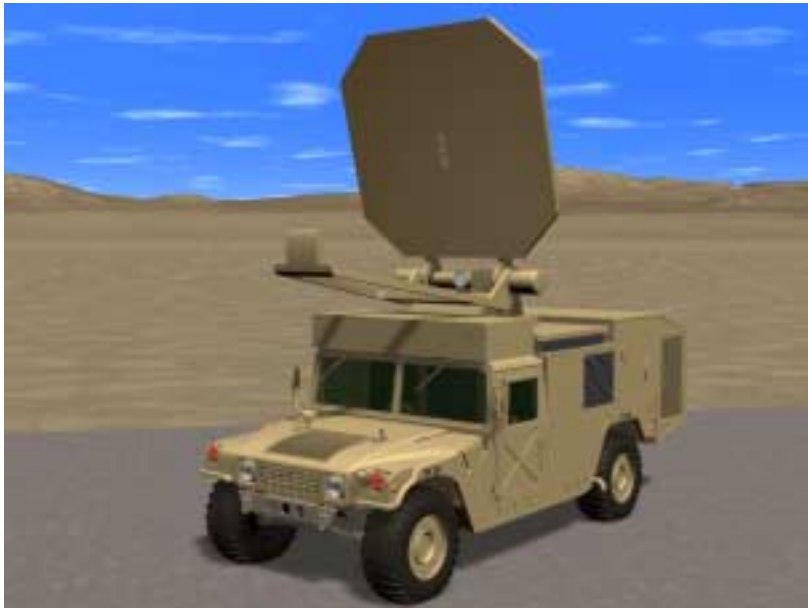
(U) Experiments Show Cancer Promotion Not Issue

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ADS OPERATIONS



**Computer Rendering of ADS
On a Vehicle Platform**

- **Maneuver to Dominating Position, Enter Standby Mode**
- **Assess Potential Targets**
- **Target Adversaries Thru Boresight Camera by Maneuvering Joystick**
- **Select Firing Mode, Depress Trigger to Fire Energy Beam**
- **Assess Target Response, Re-engage/Select Next Target**